Composites Technologies

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Manmade composite materials technologies offer significant advantages over metals when applied to structural programs and to programs where thermal problems are anticipated. Ongoing efforts at MSFC to develop composite materials and technologies for use in the DC–X/X–33/X–34 space shuttle follow-on vehicle program should pay a number of dividends for American industries.

Various composite materials have different properties that can be tailored to suit the needs of the user. For structural applications where high strength and stiffness are most desirable, carbon or graphite fibers are combined with resins to achieve the desired results with the least weight. This, however, is the most costly approach. In situations where damage resistance is paramount and weight is not a major concern, Kevlar may be substituted for carbon or graphite. The most economical material is fiberglass, but it normally has the lowest strength-to-weight ratio. Being silica-based, fiberglass works very well for thermal extremes, as the substance has a low coefficient of expansion. Regardless of the type of fiber selected, each would be combined with an epoxy or polyester resin to hold the fibers in place. A number of advanced resins have been developed for use in high-heat/cryogenic applications.

Scientists have already used composites to fabricate cryogenic fuel-pressure vessels for the Reusable Launch Vehicle program. Some of the technologies employed for this effort may soon show up in the family automobile, as attention is given to using liquefied natural gas as a low-emission fuel. Being extremely cold in its liquid state, liquefied natural gas will require an insulated, pressurized fuel tank. Insulation will probably be similar to the spray-on foam insulation now in use on the space shuttle's external fuel tank. Some work—with Thiokol Corporation, through MSFC's Technology Transfer Office—has already been completed for developing a cryogenic fuel tank for use on a minivan. Scientists are also looking at composites for use in Chrysler Corporation's proposed Patriot II Formula One racing car (which is also expected to use liquefied natural gas as a fuel contained in an insulated pressurized tank made of composite materials).

MSFC's efforts in developing composites technologies involve a number of specialized machines:

- A filament-winding machine lays down resin/fiber-composite ribbons that are built up layer by layer until a desired thickness and degree of strength is achieved. Computer directed, the device is used to make pressure vessels and similar items which have symmetrical shapes. As with many metal-working machine tools, the filament-winding machine was designed to do one job, but has been adapted to perform others.

- A pultrusion machine is similar to an extrusion machine. (Pultrusion technologies lend themselves to making long, continuous geometry tubes. Unlike metals, resin fibers cannot be pushed through a machine. It is like trying to push a rope. A strand of epoxy-impregnated resin must be pulled through the die to shape it.) A pultrusion machine is a continuously operating machine in that, once set up, it can be run for long periods of time. Pultrusion techniques have a number of structural applications; all types of fibers—carbon/graphite, Kevlar, or fiberglass—can be used, depending on the desired physical properties of the finished composite item.

- A tape-laying machine enables engineers to fabricate very large, somewhat contoured structures with asymmetrical geometries.

- A fiber-placement machine—employing a very sophisticated, computer-controlled robotic system—is the first of its kind ever built. MSFC and Cincinnati Milacron Corporation shared development costs of the device, which was initially used to make inlet ducts for the XF–22 jet-fighter prototypes. MSFC has been a leader in testing its potential applications in manufacturing composite parts with extremely complex geometries. Resin/fiber tapes can be deposited in patterns that can be narrowed or expanded.

- A tape-wrapping machine was designed to build nozzles for solid rocket motors used on the space shuttle, and it has been adapted to make nozzles for engines that burn hybrid (solid-propellant/

liquid-oxydizer) fuels and liquid fuels.

Commercial applications of **c**omposites technologies include the development of obstetrical forceps to enable physicians to position fetuses in the womb more safely in instrument-assisted deliveries. Gauges on the instrument will enable the physician to avoid placing too much pressure or stress on the infant. Also, several MSFC materials engineers have recently worked on the development of a racing wheelchair design made of composites that is now being manufactured commercially.

Sponsor: Office of Commercial Development and Technology Transfer

Industry Involvement: Thiokol Corporation, Chrysler Corporation, Cincinnati Milacron Corporation